REPORT

OF THE

BOARD OF COMMISSIONERS

OF

ELECTRICAL SUBWAYS,

OF THE

CITY OF BROOKLYN.

Dated December 31, 1894.

BROOKLYN:

1895.

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BROOKLYN, December 31st, 1894.

HON. CHARLES A. SCHIEREN,

Mayor of Brooklyn.

DEAR SIR:

The Board of Commissioners of Electrical Subways has the honor to submit the following report of work done during the year.

The total length of electrical conductors belonging to different corporations was at the date of the last report (December 15th, 1893), as follows:

MILEAGE OF CONDUCTORS IN BROOKLYN.

American District Telegraph Company	25
Brooklyn District Telegraph Company	140
Citizens Electric Illuminating Company	265
Eastern District Messenger Company	12
Edison Electric Illuminating Company	228
Holmes Electric Protective Company	11
Municipal Electric Light Company	208
New York & New Jersey Telephone Co	11,435
Postal Telegraph Company	35
Western Union Telegraph Co	308
Brooklyn Heights Railroad Company (Trolley)	712
Coney Island and Brooklyn Railroad Company (Trolley)	21
Atlantic Ave. Railroad Company (Trolley)	75
Brooklyn City and Newtown Railroad Co. (Trolley)	60
Stock Quotation Telegraph Company	35
Fire Department wires	406

The total length of electrical conductors of all kinds within the city limits at this date, Dec. 31st, 1894, is:

	Mileage.	
	Aerial.	Underground
American District Telegraph Company	150	
Brooklyn District Telegraph Company	140	
Citizens Electric Illuminating Company	285	
Eastern District Messenger Company	12	
Edison Electric Illuminating Company	....	273
Holmes Electric Protective Company	11	
Municipal Electric Light Company	248.50	
New York & New Jersey Telephone Company	3,786.37	*8,875.43
Postal Telegraph Company	35	
Western Union Telegraph Company	317.02	69.11
Brooklyn Heights Railroad Company (Trolley)	386.31	130
Coney Island and Brooklyn Railroad Company (Trolley)	23	
Atlantic Av. Railroad Company (Trolley)	75.98	
Brooklyn City & Newtown R. R. Co. (Trolley)	39.60	15.97
Stock Quotation Telegraph Company	12.75	11
Gold & Stock Telegraph Company	12.30	
Brooklyn Fire Department	557	
Brooklyn Police Department	320	7
Brooklyn, Queens County & Suburban Railroad Company (Trolley)	35.702	7.896

*Including 3,249.58 miles suspended from the elevated railways.

	Aerial	Underground
Kings County Electric Railway Company (Trolley)	77.75	
Coney Island, Fort Hamilton & Brooklyn Railway Company (Trolley)		
Nassau Electric Railroad Company (Trolley)		

In addition to the above there are in the new d stricts:

New York & New Jersey Telephone Company	400
Western Union Telegraph Company	179.31
Flatbush Gas Company	65.
Flatbush Fire Department	18.24
Coney Island & Brooklyn Railroad Co. (Trolley)	28.5
Atlantic Av. Railroad Company (Trolley)	37.69
Brooklyn Police Department	45
Brooklyn Fire Department	84

GENERAL SUMMARY.

Aggregate length of electric conductors of all kinds within city limits (omitting areas added by last legislature) is 15,914.688 miles.

Length of conductors within new areas is 857.74 miles.

Total 16,772.428 miles.

Wires underground or on elevated roads 9,380.406 miles.

Total length of aerial system within the old city limits 6,447.532 miles.

Wires buried during the year, including amount suspended as above stated, 2,005.43 miles.

Number of permits issued for construction, repairs and removals during the year is 756.

The first electric wires laid in underground conduits, under the direction of the first Board of Commissioners of Electrical Subways were drawn into the ducts in June, 1886. The work progressed during the summer, and plans were matured for a continuance of it in the Spring of 1887.

The Board of Aldermen, however, passed a resolution (December 17th, 1886,) directing the Commissioner of City Works to refuse to grant permits for opening the streets for the purposes of constructing electrical subways.

No progress was made by the Board during the Summer of 1887. An appeal to the Courts resulted in breaking the deadlock, and work was resumed late in October of the same year.

The existence of the Board terminated October 31st, 1889, at which time 3,007 miles of conductors had been drawn into the ducts and 768 miles placed upon the elevated railroads, making a total of 3,775 miles.

The present Board came into office in May, 1892, and continued the work according to the plans of construction adopted by the former Board.

Since the beginning of subway work in this city in 1886, there have been two interruptions to its progress, aggregating about three and one half years of time.

The result of the work done as shown elsewhere in this report, is that the total length of wire now in underground conduits is more than twice as great as the total of electrical conductors in the city when the first Board was organized.

The wires now on poles and housetops represent in amount only a portion of the growth of our electrical systems within the last few years. Fully sixty per cent. of all the wires within our limits are now provided with spaces in conduits or are carried by the elevated railroad structure.

It should be mentioned in this connection that a large amount of telephone wire buried in 1887–88 has been removed from the conduits, partly because of injuries incident to the locality, and partly because the experience being new at that time, the conditions incident to the situation had not been fully measured. Larger conductors were found necessary, and gradually a double wire or "metallic circuit" for each subscriber was required to overcome new difficulties that came with the trolley.

Some loss was occasioned at first through a destructive action of one of the constituents of the creosoting compound upon the lead covering of the cables. This difficulty was met by substituting an alloy for the pure lead previously employed.

The latest and most potent cause of loss in the buried cables is the electrolytic corrosion, more fully discussed elsewhere in this report. Fully four hundred miles of telephone wire have, from various causes, been rendered worthless. About three hundred miles have been rendered useless during the past year through the corrosion of the lead covering of the cables. The City wires are yet mostly on poles, awaiting an appropriation to defray the expense of an underground system.

Space has been left for City wires in the conduit of the Telephone Company, and at one time a few wires belonging to the Fire Department were drawn into one duct under Fulton street, but the conditions proved in some way unfavorable, and the wires were withdrawn and suspended beneath the Kings County elevated railroad.

A notable event of the year just closing was the beginning of the construction of conduits for the high tension arc-light conductors. The Municipal Electric Light Company began the construction of its conduit early in the summer. The Citizens' Electric Illuminating Company began its underground work in September. An aggregate length of 112,000 feet, or 21 2-10 miles of duct is prepared to receive

conductors. Cables will be drawn in during favorable weather in the winter, and the construction of conduits continued in the spring.

AERIAL SYSTEMS.

The District Telegraph Companies employ only aerial lines, which are mostly supported on housetops. To insist on the burial of these wires would abolish the system. The expense of underground conductors would render its operation, at present rates, or at any prices commensurate with the service afforded, impracticable. Clearly, then, the public interests do not require the burial of these wires. The burglar alarms and the messenger boys cannot be dispensed with, and while citizens demand this simple and serviceable means of electrical communication, the wires must remain in the air. Possibly with a more general use of the telephone, which is certain to come, the two distinct services may be performed by one system of underground conductors.

Telephone lines are extended on poles in populous districts under other conditions. These are temporary structures only, and are permitted by this Board in locations where the telephone service is desired by the residents and where the construction of an underground conduit is not at present warranted by the amount of service called for.

This Board has neither the power to construct a conduit nor to compel the Telephone Company to do so. The citizen must, therefore, either dispense with the telephone, or the telephone company must be permitted to build a pole line and maintain it until the number of subscribers shall render the underground construction financially practicable. This number varies somewhat for different localities, but under ordinary conditions the maximum limit is fifty.

The conduit when built must then have such dimensions as shall provide for the probable growth of the service for several years to come.

The extensions of underground work in the early part of next season will include several short lines which have recently reached the prescribed limit.

In some places in the city, the limit of occupation of space under the roadway is nearly reached. It is quite so in Grand Street in the Eastern district. (See plate No. 1).

The space beneath the street railroad tracks is not available for any additional constructions. The pipes of three gas companies, the

wire line of three electrical companies, the water pipe and the sewer are crowded into the remaining space.

The situation here represented may be profitably studied by the advocates of a general inclusive subway designed to contain pipes and wires of all kinds (except perhaps the sewers). Such a construction to be built in any of our city streets would require the removal of nearly all the present pipe and subway systems and their re building in the new conduit. Moreover, the space called for by the proposed new scheme would be greater than the space now occupied, inasmuch as a traversable passageway is a part of the plan.

For suburban districts destined to become populous and where the underground constructions are not yet begun, the general subway plan is an ideal one, and if it could be adopted would save much subsequent inconvienence. The ownership of such a subway should obviously rest with the city.

The subject of corrosion of water pipes, gas pipes and coverings of telephone cables, through the electrolytic action of the current escaping from the Trolley rails, was discussed at length in the report of this Board, submitted in January last.

The fear was then expressed that harm was being done to pipes of the water supply system. That fear is not allayed by such examinations as it has been possible to make in the meantime, but the Board reports, with satisfaction, that the areas within which such injury can be done are clearly defined, and that quite certain means of arresting the destruction have been found.

A full report of the electrical survey of the City by Mr. John A. Barrett, under the direction of the Board, is made (together with a map) a part of this report.

On October 20, 1894, the New York and Eastern Telegraph and Telephone Company made an application to this Board for permission to string wires on the structure of the Kings County Elevated Railroad Company, and to lay subways in certain streets of the City of Brooklyn.

This application was refused by the Board, for the reason that this company was not incorporated in the State of New Jersey under the

Telegraph and Telephone Act of that State, but under the General Incorporation Act, and was, therefore, incompetent to transact a telegraph and telephone business in this State, as this Board was advised by counsel.

On the application of this company to the Supreme Court, Mr. Justice Gaynor issued a writ of mandamus, dated November 28, 1894. requiring this Board to issue the desired permissions; this order was appealed from to the General Term of the Supreme Court, a stay of proceedings having been granted. The appeal has since been argued before the General Term, and decision thereon not yet handed down.

The refusal of the Board to issue the permissions desired by the New York and Eastern Telegraph and Telephone Company was based on the act of the Legislature creating this Board, and requiring it to issue permissions to "duly authorized companies" only, said act being Chapter 499 of the Session Laws of 1885.

Explanation of the Plates Showing Examples of Electrolysis.

The examples of corrosion exhibited in plates Nos. 2, 3 and 4 are from photographs of water pipes. Iron, copper and lead are all represented in the samples.

Figures 1 and 2 are sections of an iron pipe corroded at a screw-joint. No. 2 shows the normal thickness only $1\frac{1}{2}$ inches from the joint. Fig. 1 shows the effect of the current at the joint of another section of the same pipe. This was a water supply pipe of $1\frac{3}{8}$ inches outside diameter, from Jewell's Mills near Fulton Ferry.

No. 3 is a copper drip-pipe from the same locality. It had a diameter outside of one inch, and was reduced to the condition shown in the figure in seventeen days.

The electrical conditions of the trolley track and the water of the Bay as exhibited on the map will serve to explain the cause of this rapid destruction, especially when it is added that the corroded end although one hundred yards from the Trolley track was immersed in water.

Figures 4 and 5 represent pieces of lead pipe sent to the office of this Board from Marston's coal yard in Water street. The following explanation came with the samples: "we have a line of water piping

running from our building at 21 Water street to engine house on the dock, a distance of about 400 feet. This pipe, previous to the middle of June, 1893, had been in continuous use without repairs for about 20 years. At the time last mentioned our water meter indicated a large increase over the normal consumption and on examination the old pipe proved to be used up; so we substituted a first class galvanized iron pipe on June 26, 1893.

About the first of Dec., 1893, the meter again indicated an unusual flow and in looking for the trouble, discovered that the new pipe was so thoroughly honey-combed with holes that it was leaking badly all along the line. Our conclusion at that time was that the pipe must have been inferior, so to make ourselves doubly secure in the future we took it all up and laid a heavy lead pipe. On the second of this month (Aug. 1894), we experienced the same difficulty again and upon opening up found the new lead pipe nearly destroyed and leaking in several places.

All of these pipes were laid in a trench about 3 feet, 6 inches deep and enclosed in a 5 inch by 5 inch spruce box or trough of 2 inch stuff coated with coal tar. The box was filled in around the pipe with clean builders' sand. Upon investigation since we have had these experiences, we are led to believe that the damage has been caused by the action of the electrical current from the Trolley lines passing our door. The pipes in every instance were of the best quality and put in by an experienced plumber and under our own supervision."

No. 6. Plate 4 represents an iron service pipe from Thirty-ninth street. It is $\frac{3}{4}$ inch outside diameter. The distance from the Trolley rail was not given. But in several other instances pipes located within three feet of the track have been brought to the condition shown here in about two years.

The facts thus recited and illustrated serve to continue the record of last year's report, and to emphasize the conclusions regarding possible undetected injury to the water pipes belonging to the City.

This board finds cause of congratulation in the fact that the recent survey not only defines the limit of active injury, but specifies a means of prevention.

Among other inconveniences resulting from the possible or probable destruction of underground pipes, was (so long as the problem of

prevention or cure remained unsolved) the restriction it naturally imposed on the burial of electric conductors.

Respectfully submitted,

GEO. W. PLYMPTON,
FRED R. LEE,
Commissioners.

REPORT OF THE ELECTRICAL SURVEY MADE BY DIRECTION OF THE BOARD.

To the Board of Commissioners of Electrical Subways of the City of Brooklyn.

GENTLEMEN :

Acting in accordance with your purposes, I have directed a survey of some of the subterranean Electrical conditions produced by the operation of the Trolley Railroads in Brooklyn.

The work was begun on the 5th of October, and while the extensiveness of the territory involved and the great variety of circumstances introducing unusual complications into the problem in this City, have precluded anything more than a partial investigation up to the present, I submit the following report of such observations as appear to have a practical value ; together with some suggestions, and a description of a few actual changes which have been introduced into the system for the purpose of correcting certain localized phases of trouble.

The valuable original contributions of Mr. I. H. Farnham, of Boston, and of others in other cities in establishing the fundamental facts of Electrolysis by Trolley Earth Currents enabled us to pass over much preliminary work and to enter at once upon an actual survey of the local conditions in Brooklyn.

The most considerable part of the time and labor with us has been occupied in securing measurements upon the Electrical status of the public water pipes by tests chiefly made at the street hydrants along the lines of the Trolley roads. From figures thus obtained the map accompanying this report has been prepared.

In this general survey, measurements were made at 660 hydrants, covering somewhat over 100 miles of street. The full system of measurements comprised taking differences of potential between hydrant and rail, between hydrant and at least three earth points, and between the same earth points and the rail ; and in some instances between hydrant and gas pipes, and between hydrant and elevated railroad structure.

The differences of potential, discovered by these measurements indicate whether there is a tendency of electrical current to pass either to or from the water pipes in the vicinity of the hydrant under observation ; and also the degree or intensity in which such a tendency exists. In other words the figures representing differences of potential between the hydrant and the earth or conductors imbedded in the earth, correspond with conditions of electrical pressure acting either from or towards the water pipes within a limited distance of the hydrant. As a basis for estimating the practical value of these figures, it is to be noted that a current of electricity entering upon the pipe from the earth, does not promote the corrosion of the pipe at the surfaces by which it enters. If such a current has any material influence it rather retards natural corrosion. It is where a current of electricity passes from the surface of a pipe into the earth or into any wet or watery conducting medium that the corrosion of the pipe is actively stimulated. Consequently, when the measurements indicate that the

electrical pressure is towards the hydrant, the water pipes in that vicinity are regarded as for the present comparatively safe from damage by the Trolley currents ; but when the direction of pressure is outward from the hydrant, then the neighboring water pipes are believed to be under a liability of accelerated corrosion.

It is to be further observed that a pressure outwardly from a pipe merely indicates a liability to corrosive action and does not necessarily determine the existence and locality of specific ins ances of damage. Considerable differences of potential may exist from the pipes to the railroad system, where there is an absence of suitably associated conditions of conductivity in the Earth, and where consequently there will be no current sufficiently localized to produce material damage. On the other hand, smaller differences of potential, together with favorable conducting paths through earth or water will cause rapid destruction of the pipes.

In general, the conditions existing in Brooklyn concerning the trolley earth currents are similar to what are reported from other large cities. The single Trolley is the only system in use here. The positive pole of the generators is connected to the outgoing trolley wire. The current descending from the overhead wire through the cars of the system to the rail, seeks a return to the power station, and in its return distributes itself naturally over the several paths offered to it.

In proportion to the superior conductivity of the rail and supplementary and special return feeders, the principal part of the current harmlessly follows these proper conductors back to its source. But it is found that even with the most extensive system of return conductors provided by any of the Brooklyn roads, the potential of the rail throughout the central portions of the city, and in districts remote from power stations is generally higher than that of the earth and water pipes, and that consequently there is in these districts a continuous passage of current from the rails through the earth to the water pipes.

It has previously been stated that this passage of current to the pipes is not the occasion of damage in the localities where it occurs. But all the electricity which is received by the pipes in such localities must pass along the pipes to other places where it will leave the pipes, and where it will produce an amount of damage proportioned to its volume and the concentration with which it flows. The places where the accumulated current chiefly tends to leave the pipes, are found to constitute well-defined districts, generally immediately surrounding power stations, since here the short and heavy negative feed wires from the rails to the generators tend to lower the potential of the rails below that of the neighboring pipes. It is, then, the general rule briefly stated that electricity is flowing to the water pipes from the rails in portions of the city remote from power stations, and is passing along the pipes towards the respective power stations, and at points mainly located within districts near to power stations the electricity which has been gathered throughout the more distant territory and brought so far on its way to the power stations is flowing from the pipes through the earth to the rails and other short return paths to the generators.

I regard it as important to give this now common proposition special prominence and emphasis because so far as it is applicable to the conditions it both underlies and indicates the means which are serviceable against damage by the Trolley earth currents.

An inspection of the map will give a comprehensive view, showing the demarcation of districts in accordance with this proposition. The figures upon the map which are printed in black indicate a difference of potential tending to cause a movement of current towards the water pipes. The red figures indicate an outward pressure, tending to cause the electricity which is upon the pipes to flow off into and through the earth to some conductor leading more directly to the power station. But while it will be observed that the principal groups of red or danger figures are generally in districts near to power stations, the situation in this City is one of peculiar complexity, the result of which is illustrated by some exceptional displacements of red groups into districts not in the vicinity of a power station ; as also by a scattering of isolated red figures in different parts of the City.

Chief amongst these peculiar and complicating conditions is the operation of four principal and independent Trolley railroads, with seven power stations in irregular and scattered positions, and with intricately crossing and interlacing lines of track.

Lack of any common standard, as to system of feeders, supplementary wires, and returns, adds to the confusion. The extensive water front of Brooklyn, and the situation of two large power stations directly on the shore, and of two other power stations on Gowanus Canal, all with negative plates of considerable capacity sunk in the water, together with the discharge of a heavy burden of current from the cars into the central peninsular between Wallabout and Gowanus, constitute an important special feature in the distribution of the earth currents. From this latter combination of circumstances there appears to be an almost continuous line of dangerous potentials upon the water pipes along the shore, from the Navy Yard to Erie Basin. These dangerous potentials are indicated on the map by red figures upon arrows pointing outwardly from the shore.

The conditions about Gowanus Canal also are seriously compromising to the safety of water pipes in that neighborhood ; but the intricacies of the problem due to the relative situation of two power stations on the Canal, and three independent lines of road interlacing with each other in the immediate vicinity, would require much more time than could be allotted to it in order to locate and determine the extent of probable damage, and to indicate what would better be done to remove or diminish the trouble. It will be seen on the map that the red or danger figures which might be expected to appear on Smith and Ninth streets, near power station F, are transferred from the street to the hydrants along the borders of the Canal. The exact causes of so complete a transfer were not ascertained, but such tests as could be made indicated that it is in part due to a negative connection from the generators to a driven well near the Canal, together with overloaded return wires from the rail system.

On account of the limitation of time and expense under which the work was carried on, making it necessary to discriminate against undertaking much which is obviously desirable to be done, it was determined that after securing data for the map, and so obtaining a general view of the situation, we should devote the remaining time to applying certain corrective methods, with the object of demonstrating, if possible, that the damaging conditions could readily and materially be improved.

From among the danger districts, defined upon the map by the groups of red

figures, within which the corrosion of the water pipes is being actively promoted by the Trolley currents, I selected that lying along Second and Third avenues from Twenty-fifth street to Sixtieth street, for such special work as we were authorized to undertake.

The outlying situation of this district and its power station at Fifty-second street, with regard to other power stations and crossing roads, make the conditions here affecting earth currents comparatively simple. In respect to actual damage to water pipes in this district, the figures deduced from the measurements and represented upon the map are sufficient to show that electrolytic corrosion to a serious extent is going on. I am informed that numerous instances of destruction to service pipes have been reported. I have not personally investigated any of these cases. One excavation was made under my observation at the corner of Third avenue and Fortieth street exposing a portion of the water main and branch at the junction of these streets, but upon a close examination no corrosion was discovered which could be attributed to the effect of Trolley currents. At the same time there exists from the mains to the earth and rails a sufficient pressure to cause a destructive flow of electricity at any place where the moisture in the soil, or other favorable conditions, has established a suitable path for the current. It seems probable that the long service pipes which run across the street at short intervals and in comparatively close proximity to the rails are more liable to local damage than the mains, and that they draw off upon themselves some proportion of the trouble which would otherwise appear upon the mains. Still I am of the opinion that more extensive excavations would discover abundant evidences of serious electrolytic corrosion upon portions of the mains.

Regarding the question of corrective measures, a leading purpose in this report has been to demonstrate with special clearness and emphasis that there are two things to be done which will materially diminish if not altogether remove the disastrous action of Trolley currents circulating according to the general rule which has previously been described.

The first thing to be done is so far as practicable to keep the railroad electricity off the pipes in all those regions where there is a tendency of the current to overflow from the rails to the pipes. The one method by which this over flow may effectually be diminished is to provide a more liberal system of return conductors than at present prevails, at least on some portions of the Brooklyn railroads. The limit to which the perfection of the return system should be pushed ought to be fixed only by considerations of reasonable cost.

After everything that is reasonable has been done in this direction, there will still be a large overflow of current from the rails which will be collected by the pipes and will be conveyed along the pipes to points where the conditions favor its discharge again into the earth.

The second thing to be done is to locate, by careful investigation, the points where this large and unavoidable residue of earth current tends to leave the pipes; and, by a system of special return wires directly connected at brief intervals to the pipe mains, to draw off as much as possible of the accumulated electricity harmlessly from the pipes, and thus to obviate the electrolytic action which is sure to accompany the passage of the current directly from the surfaces of the pipes into the earth.

These two methods of treatment have frequently been proposed:

It is important to associate the two steps in their proper relations with each other. In general, the attachment of the lead wires to the pipes in the danger districts should not be undertaken until an adequate system of outlying returns has been provided by the railroad companies. After all that is practicable has been done to convey back the railroad current to the power stations by proper return conductors, then the pipes in the vicinity of power stations may be relieved of the unavoidable overflow by lead wires correctly applied. Under these conditions the railroad companies will be prevented from relying upon the underground pipes, particularly the water pipes, as a material and proper part of their return systems, and the pipes, so far as regards the principal circulation of Trolley currents, would virtually be safe.

The exceptional location of danger spots, due to causes which have been mentioned, and to other more obscure causes, and especially to the relations between gas and water pipes, will remain to be hunted out, and a remedy applied to each specific instance. Such an investigation would include a study of the relations between the systems of independent railroads, and the effect of earth plates. The remedies, after adequate and properly related systems of returns have been provided, would consist chiefly in electrically uniting different lines of pipes at suitable points, in establishing metallic connections between pipes and rails at places indicated by the conditions, and, in general, in drawing the electrical charge off from the pipes by the direct attachment of negative feed wires wherever a dangerous accummulation is found.

Returning to the case of lower Third avenue, we could not expect to interfere with the general system of returns in use by the company owning this line, but I found the conditions much more complete and satisfactory for our purpose than was expected, and the officials and engineers of the road ready to aid the work as fully as could be desired.

A negative feed wire, containing 500,000 C. M. of copper, was run by the railroad company up Third avenue from the power station on Fifty-second street as far as Twentieth street. From this feeder connections were made to the hydrant service pipes near Twenty-fourth street, Twenty-sixth street, Twenty-eighth street and Thirty-second street, with the general result of changing the electrical condition of the mains from dangerous to safe as far down as Thirty-third street, excepting an intermediate spot near Thirtieth street, which would be corrected by a connection made at this point. A similar connection was made at a hydrant between Forty-fourth and Forty-fifth street. The protective influence of this isolated attachment does not appear to extend beyond a block in either direction.

At this time it was discovered that there is a considerable flow of current from Fifth avenue down the pipes in the cross streets to Third avenue. This probably arises from some interchange of current between the Third avenue line and the roads operating on the park slope.

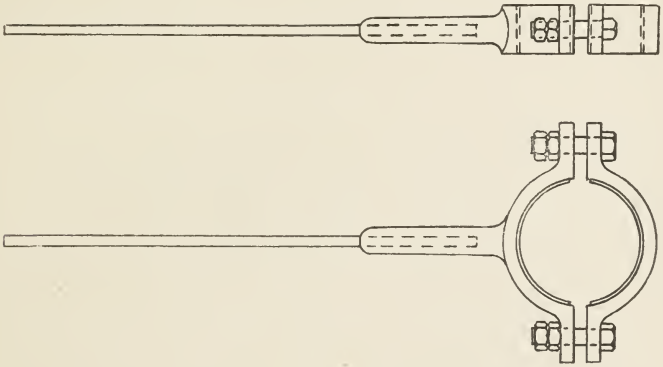
It was decided that this inflow of current would best be met by making the future connections to the pipes at the junction of the cross streets with the avenue, and one such connection was made at Thirty-fourth street and Third avenue with favorable results.

I do not insert here a detail of the figures obtained by tests of these changes, because there is a confusing variation due to the varying loads and the different

times of day at which the tests were made, and we could not delay to reduce them to a common standard for tabulation. It will be observed on the map that the danger figures vary up to a maximum of two volts. After the protective connections are made the difference of potential runs to about the same degree in the opposite direction. It had been hoped to cover the whole of the danger line on Third avenue at least, but the work was necessarily left incomplete at this point.

A full detailed record of every test which has been made in this survey is on file in your office.

I desire to describe in particular the means which were employed for making the attachment to the water mains, since it has been questioned whether it were practicable to insure the permanence of such connections. The accompanying cut shows the form of clamp made for the purpose under the direction of Mr. M. G. Starrett, Chief Electrician of the Brooklyn City Railroad.



The collar is of wrought iron in two parts $\frac{5}{8}$ of an inch thick and two inches broad. The two parts are drawn together by $\frac{3}{4}$ inch bolts with two nuts to each bolt. The collar is previously turned out upon its inner face to $\frac{1}{4}$ of an inch larger than the diameter of the pipe to which it is to be applied. Midway in one part is formed a lug into which is brazed a No. 00 Copper wire.

In applying the connection the pipe is carefully brightened all around with a file. A strip of bright lead 5-32 of an inch thick and $2\frac{1}{2}$ inches broad is laid around the pipe and the collar is clamped down by the bolts until the lead gasket is mashed into the inequalites of the pipe. The lines of junction between the collar and lead and pipe are thickly painted over with "*P. B.*" mixture ; then completely taped over and again painted with "*P. B.*" upon the tape ; after which the whole is thoroughly packed with good cement. I do not regard the thoroughness of this method as excessive in view of the requirements of the case.

One element in this problem of earth currents which should be mentioned as of great importance is the relation between water and gas pipes. The independence and extent of the two systems of pipe undoubtedly produce situations where there is a strong localization of current through the earth from one to the other, and where that pipe is being continuously corroded from which the current is flowing.

After the foregoing presentation of the matter and in view of the actual developments in this and other cities where single Trolley roads are being operated, it is unnecessary to go to any length in asserting the gravity of the situation.

It will be sufficient to state summarily that under the present condition in Brooklyn it appears indisputable that earth currents from Trolley roads are causing extensive Electrolysis of water pipes and other pipes and conductors imbedded in the ground, at an indeterminate but serious rate. It also appears that there are practicable means at command which are being neglected, and which if properly organized and applied, would largely abate if not altogether arrest the ongoing destruction.

I have the honor to be

Yours respectfully,

JOHN A. BARRETT,
Electrician.

APPENDIX.

UNDERGROUND CONDUITS IN EUROPE.

Consular officers of the United States, resident in European cities, were instructed by a general order, bearing date June 9, 1891, to prepare a report on the subject of underground conduits for telephone, telegraph and electric light wires, and for electric power cables in their several districts.

The following brief notes are abstracts from the consular reports, published by the Department of State, Washington, in 1892.

AUSTRIA-HUNGARY.

VIENNA.

There are at present (Nov., 1891) about 70 miles of underground telephone wires laid in trenches along the sidewalks.

No telegraph wires are underground, with the exception, perhaps, of a line from the War Department to the different barracks. Three electric light companies have collectively about 55 miles of lead-covered cable in trenches underground.

No provincial towns of that district have, so far as known, underground cables of any kind.

BELGIUM.

ANTWERP.

Only one underground conduit in the City.

It is used for telegraphic purposes. It contains about 50 wires, and has a total length of 1,290 meters (about 4-5 of a mile).

LIEGE.

One underground line, containing two telegraph cables.

Total length, about half a mile.

BRUSSELS.

No telephone or electric light conduits in the City.

The length of telegraph conduits is about 2 1-5 miles.

The total length of underground cable in Belgium is 14¼ miles, or about 109 miles of wire.

DENMARK.

COPENHAGEN.

For telephone purposes about $2\frac{1}{3}$ miles of conduit have been constructed, containing 12 6-10 miles of single duct, each duct capable of holding a fifty wire cable. There is also an iron bound cable, 2 1-7 miles long, buried in the ground.

Telegraph conduits at this date (July, 1891) have an aggregate length of $4\frac{1}{4}$ miles, and contain about 84 miles of wire.

In the near future the conduits are to be extended to a length of $6\frac{3}{4}$ miles, and the wires to 278 miles.

For electric lighting purposes, insulated cables are mostly used, and are buried under the sidewalks. The total length of such conductors is not stated.

FRANCE.

LYONS.

All electric conductors are placed in the sewers, wherever the sewers extend. There are no special conduits for wires.

MARSEILLES.

All telephone wires are overhead, mostly on house tops; electric power is not distributed.

The only underground conduits are those for telegraph lines and for electric light conductors

NANTES.

Telephone and telegraph wires of this district are government property, and the anthorities refuse to give information about them. Not many conductors of this kind are underground.

The burial of electric light wires was in progress at the date of the report (March, 1892), the contract requiring that 18 kilometers (11 miles) should be laid in two years.

Streets were lighted here by electricity for the first time in January, 1892.

TOURS.

This City is almost entirely lighted by electricity.

The wires are in part suspended, and in part placed in underground conduits.

CHATEAULIN, ST. BRIEUC, ST. NAZAIRE, HENNEBONT, SAUMER.

These Cities are partially lighted by electricity. The wires are all in the air.

ROUEN.

Wires are in the air, attached to the roofs or sides of houses in the most primitive way.

GERMANY.

BERLIN AND HAMBURG.

The extension of the telephone system of late years in these two cities had so burdened the roofs that exclusive use of this plan seemed no longer practicable. Underground accomodations were, therefore, rendered necessary. These were practically completed in 1888–90. The telephone cables containing 28 wires each are drawn into iron pipes.

The pipe system in Berlin has a total length of 34 kilometers (21 miles). The amount of wire laid in conduits during the year 1891 was 2,266 miles.

The underground system of Hamburg is on the same plan as that of Berlin. The pipe conduits had an aggregate length Feb. 1, 1892, of 7 kilometers (4 3–10 miles), and were to be extended at once. The length of wire in conduits at that date was about 690 miles.

BREMEN.

All telephone wires are overhead. A government telegraph cable extends underground through the city. Its length is 10 kilometers (6.15 miles).

There is an electric light conduit belonging to the State extending to the warehouses and streets about the port.

COLOGNE.

The only underground wires are those for telegraph and electric light. Telegraph cables are loosely buried in the earth about one meter deep. The electric light cable is in a wooden box three feet under the sidewalk.

DRESDEN.

No conduits as yet (July, 1891), for telephone, electric light or power cables. The government telegraph only is underground.

FRANKFORT.

Taking Frankfort as a fair example of the larger and most progressive German cities, we find here the telephone wires strung not through the streets on poles, but high overhead upon iron frames and posts projecting above the roofs of the tallest buildings. There is no general system of electric lighting or power distribution here.

The telegraphs belong to the government and all telegraph wires are laid underground in the shape of cables within the corporate limits of Frankfort and most other government cities.

The length of cable belonging to the imperial telegraph system was in 1891, 3 600 miles, containing 24,300 miles of wire.

THE NETHERLANDS.

The total length of underground wire for telegraph and telephone purposes is about 92 miles. Electricity for lighting is far less used in the Netherlands than in the United States.

ITALY.

FLORENCE.

No underground conduits for telephone wires are to be found here. A small number of conductors for electric lighting have been placed underground, but with unsatisfactory result.

MILAN.

Two electric lighting systems are in use here; an Edison system, with an underground development of about 22 miles, and a Thomson-Houston system, employing about $9\frac{1}{4}$ miles of underground wire and 62 miles aerial.

ROME.

No underground wires for conveying electricity.

PORTUGAL.

LISBON.

One mile of electric light wire is laid under the main avenue. No other wires are underground.

SPAIN.

BARCELONA.

The only wires that are put under ground in this City are the private electric lighting wires, and the cables of the Government and of the Direct Spanish Company. Telephone and telegraph wires and the wires for the two hundred arc lamps in the streets are all suspended in the air.

CADIZ.

No underground conduits for electric wires of any kind. The streets are narrow, and the gas pipes, water pipes and the sewer leave no available space for electric conduits.

SWEDEN.

STOCKHOLM.

At the date of the report (August, 1891), electric conductors of all kinds were overhead. Preparations were being made, however, to bury telegraph and telephone wires belonging to the government.

THE UNITED KINGDOM.

LONDON.

The English Postal Telegraph Underground system consists of copper wires insulated with gutta percha and drawn loosely into cast iron pipes placed a short distance below the surface, generally of the sidewalk.

There are several large subways in London; eight in all are specified whose aggregate length is about 4 miles. They have been mostly constructed in connection with large works of improvement.

The longest one 7,000 feet is under the Victoria Embankment. It has a cross section measuring $7\frac{1}{2}$ by 9 ft. A conduit under Northumberland avenue is $7\frac{1}{2}$ by 12 ft. in cross section and 925 feet long. (The consular report makes no mention of telephone wires other than those connected with the Postal system. In 1892, they were on housetops.)

LEEDS.

There is no general system of conduits for telephone, telegraph, electric light or electric power wires in this district.

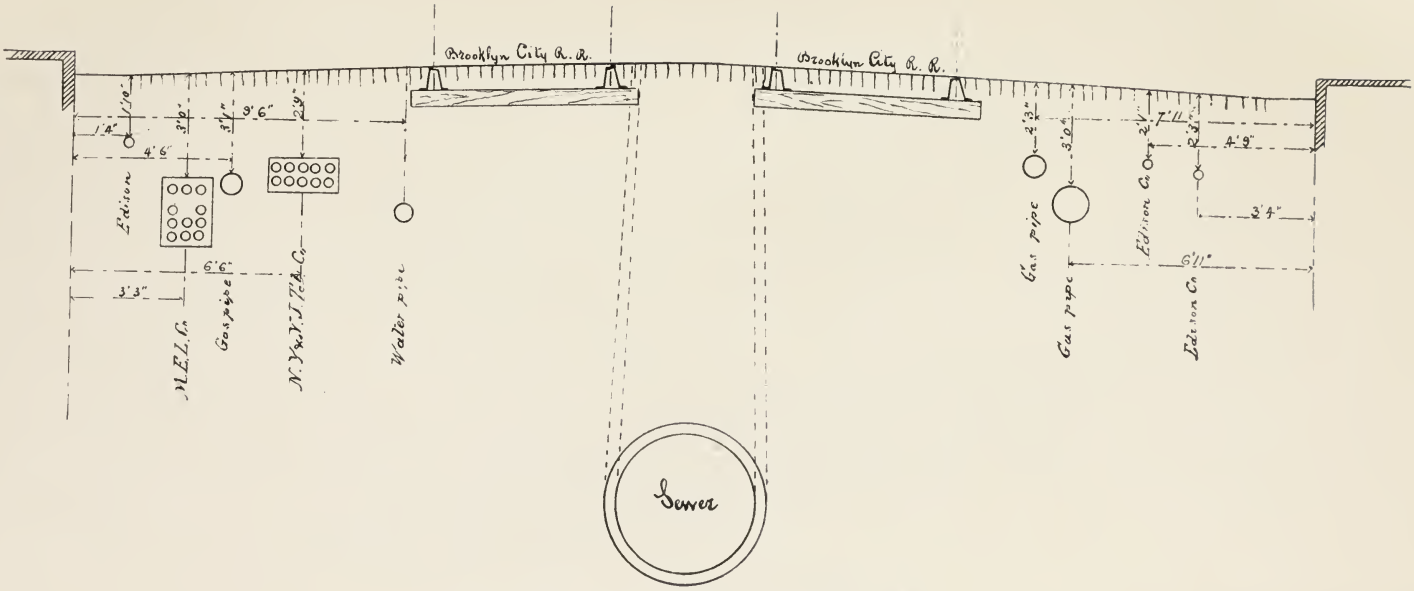
In one place a telephone cable leading from a central station extends through a 3 inch cast iron pipe for a mile and a half underground. A telegraph cable is also laid in a pipe of the same size for a length of eight miles to the outlying districts where the system is continued as a pole line.

LIVERPOOL.

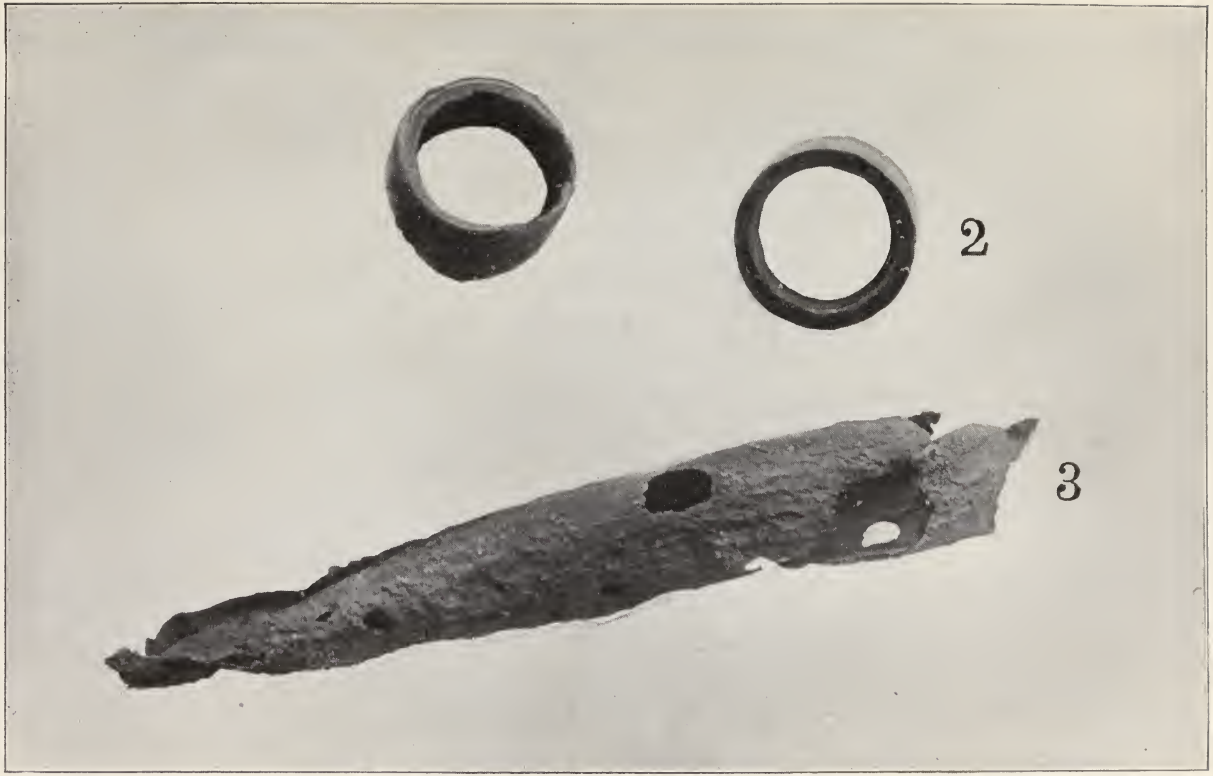
In this city the system of incandescent light wires is altogether underground and the Post office telegraph wires are laid underground wherever the number of wires running in a common direction is sufficiently large to warrant the expense of a conduit and maintaining it in working order. As to telephone wires it is stated that the system is entirely aerial.

There is absolutely no system of wires intended for the transmission of electricity as a motive force.

The electric light is supplied to a few residences and only in rare instances is it used for street illumination.



CROSS SECTION AT GRAND STREET AND DRIGGS AVENUE.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